

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re PATENT APPLICATION OF

Confirmation No.:

YAMAGATA et al.

Group Art Unit: (Unknown)

Divisional of: 09/692,162

Examiner: (Unknown)

Parent Filed: October 20, 2000

Divisional Filed: August 10, 2001

Title: SUBSTRATE MATERIAL FOR MOUNTING
A SEMICONDUCTOR DEVICE, SUBSTRATE
FOR MOUNTING A SEMICONDUCTOR DEVICE,
SEMICONDUCTOR DEVICE, AND METHOD
OF PRODUCING THE SAME

August 10, 2001

* * * * *

PRELIMINARY AMENDMENT

Hon. Commissioner of Patents
Washington, D.C. 20231

Sir:

Please preliminarily amend the above-identified Application as follows.

IN THE SPECIFICATION:

Page 1, line 13, change the paragraph to read:

2. Description of the Prior Art

Page 1, lines 14-21, change the paragraph to read:

With the recent remarkable increases of the processing rate of semiconductor devices and the degree of integration in semiconductor devices, the heat generated by semiconductor elements has come to produce influences that are not negligible. As a result, substrate materials for mounting semiconductor devices have come to be required to have a high thermal conductivity for efficiently removing the heat generated by semiconductor elements.

Page 9, lines 21-26, change the paragraph to read:

Aluminum/silicon carbide composite alloys have a high degree of hardness.

Therefore it is very difficult to form a shape, especially a complex shape such as heatsink by

using aluminum/silicon carbide composite alloys. It is required that a substrate material is able to be formed easily to be near net shape precisely.

Page 10, lines 2-9, change the paragraph to read:

In view of the current situation as described above, an object of the present invention is to eliminate the problems concerning precision in forming, cost, etc. to provide a substrate material for mounting a semiconductor device, made of a lightweight aluminum/silicon carbide composite alloy which has a homogeneous composition and has the properties required of a substrate material, i.e., a thermal conductivity of 100 W/m·K or higher and a thermal expansion coefficient of $20 \times 10^{-6}/^{\circ}\text{C}$ or lower.

Page 10, lines 13-17, change the paragraph to read:

Another object of the present invention is to provide a method of forming a substrate which has a thermal expansion coefficient with a large range so as to be appropriate for a semiconductor chip or a package to be fixed to the substrate.

Page 10, line 20 through page 11, line 7, change the paragraph to read:

To accomplish the above objects, the present invention provides a substrate material for mounting a semiconductor device, made of an aluminum/silicon carbide composite alloy which comprises an Al-SiC alloy composition part and a non alloy part and dispersed homogeneously silicon carbide granular particles. Silicon carbide granular particles are dispersed from 10 to 70% by weight in the composite alloy, and silicon carbide is distributed homogeneously in the Al-SiC alloy composition part. And the fluctuations of silicon carbide concentration in the Al-SiC alloy composition parts is within 1% by weight, and which has a thermal conductivity of 100 W/m·K or higher and a thermal expansion coefficient of $20 \times 10^{-6}/^{\circ}\text{C}$ or lower.

Page 12, lines 14-20, change the paragraph to read:

The sintering process of the present invention for producing an aluminum/silicon carbide composite alloy, is especially capable of yielding an aluminum/silicon carbide composite alloy having a thermal conductivity of 180 W/m·K or higher by regulating the sintering temperature to a value in the range of from 600 to 750°C to thereby control the interfacial reaction which yields the aluminum carbide and the silicon.

Page 15, lines 3-13, change the paragraph to read:

In the present invention, an aluminum/silicon carbide composite alloy useful as a semiconductor substrate material is produced by sintering to thereby provide a semiconductor substrate material having the desired values of thermal conductivity and thermal expansion coefficient and having a homogeneous Al-SiC composition and a near-net shape, i.e., excellent dimensional precision, the attainment of both of which has been difficult in conventional processes. This substrate material is capable of coping with, not only conventional ceramic packages, and metal packages but also in particular, plastic packages, flip chip bonding, and ball grid array bonding.

Page 15, line 23 through page 16, line 14, change the paragraph to read:

The crystal forms of silicon carbide include hexagonal α -SiC form, which is formed at a high-temperature, and cubic β -SiC form, which is formed at a low-temperature. Although these two forms do not differ in the thermal conductivity of an alloy, α -silicon carbide is susceptible to cleavage. Due to this property, use of α -silicon carbide in a starting powder is apt to result in silicon carbide cleavage due to the pressure applied during compaction into a desired substrate shape. As a result of the cleavage, the compact may contain aggregates made up of fine silicon carbide particles. Since the aggregates have poor adhesion to aluminum in an alloy, they tend to suffer debonding of particles when the alloy is subjected to processing such as grinding, barrel, shot blasting, etc. in the final step. It is therefore desirable to use β -silicon carbide or a mixture of α -silicon carbide and β -silicon carbide. "Debonding of particles" means that particles are displaced from the position to be in the alloy, and the surface of the alloy grows porous.

Page 22, lines 14-25, change the paragraph to read:

In ordinary sintering, densification is generally inhibited by the gas remaining within the alloy. However, the use of nitrogen as a non-oxidizing atmosphere was found to be effective in densification because the nitrogen gas remaining within the alloy turns into aluminum nitride through reactions with aluminum. An alloy containing nitrogen especially in an amount of 0.01% by weight or larger is advantageous for attaining a thermal conductivity of 180 W/m·K or higher. However, if the content of nitrogen exceeds 1% by weight, densification is inhibited rather than enhanced. Therefore the preferred range of the nitrogen content in the aluminum/silicon carbide composite alloy is from 0.01 to 1% by weight.

Page 24, line 24 through page 25, line 2, change the paragraph to read:

And according to aluminum/silicon carbide composite alloys formed as above, a substrate can be formed precisely to be near net shaped or in net shaped without warp or deform. In this case it is not required to machine process with respect to the whole surface.

Page 34, lines 11-20, change the paragraph to read:

The starting powders obtained were compacted at a pressure of 7 t/cm^2 to obtain tablet test pieces having a diameter of 20 mm and a height of 30 mm. These compacts were sintered at 700°C for 2 hours in a nitrogen atmosphere having a nitrogen concentration of 99% by volume or higher. As a result, aluminum/silicon carbide composite alloy sinters were obtained which retained the original shape of the compacted test pieces. However, the alloy of sample 9 was not dense and had voids in a surface layer thereof; this alloy was hence not subjected to the following measurements.

Page 36, line 16 through page 37, line 2, change the paragraph to read:

The starting powders obtained were compacted at a pressure of 7 t/cm^2 to obtain tablet test pieces having a diameter of 20 mm and a height of 30 mm. These compacts were sintered in a nitrogen atmosphere to remove a binder. Then after degassing the tablet test pieces in a pressured chamber, they were pressure-infiltrated in an aluminum melt. As a result, aluminum/silicon carbide composite alloy having silicon carbide contents of 71 % by weight were obtained. It was difficult to obtain aluminum/silicon carbide composite alloy having silicon carbide contents of less than 70 % by weight by similar method. Because more porosity in the formed silicon carbide compact is required, and the formed silicon carbide compact is not stiff enough to keep its shape.

Page 53, line 21 through page 54, line 7, change the paragraph to read:

An aluminum powder having an average particle diameter of $25 \mu\text{m}$ was mixed with a silicon carbide powder having an average particle diameter of $35 \mu\text{m}$ in such a proportion as to result in a silicon carbide content of 50% by weight. The mixture was homogenized with a kneader for 1 hour in the same manner as in the above Examples. Thus, an aluminum/silicon carbide starting powder was obtained. The starting powder obtained was compacted at a pressure of 7 t/cm^2 . The resultant compacts were sintered at 700°C for 2 hours in a nitrogen

atmosphere having a nitrogen concentration of 99% by volume or higher. As a result, aluminum/silicon carbide composite alloy sinters were obtained which retained the original shape of the compacted test pieces.

Page 61, lines 2-8, change the paragraph to read:

The starting powders obtained were compacted at a pressure of 7 t/cm² to obtain test pieces having dimensions of 100 mm by 25 mm by 2 mm (thickness). These compacts were sintered at 700°C for 2 hours in a nitrogen atmosphere having a nitrogen concentration of 99% by volume or higher. As a result aluminum/silicon carbide composite alloy sinters were obtained which retained the original shape of the compacted test pieces.

See the attached Appendix for the changes made to effect the above paragraphs.

REMARKS

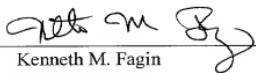
Consideration and allowance of the present Application is respectfully requested. The above amendments to the specification are grammatical in nature and no new matter is added to the Application.

Claims 35-49 are pending in this Divisional Application.

In view of the foregoing, the claims are now believed to be in form for allowance, and such Action is hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, he is kindly requested to contact the undersigned at the telephone number listed below.

Attached hereto is a marked-up version of the changes made to the specification by the current amendment. The attached Appendix is captioned "Version with markings to show changes made".

Respectfully submitted,
Pillsbury Winthrop LLP

By: 
Kenneth M. Fagin
Reg. No.:37,615
Tel. No.: (703) 905-2066
Fax No.: (703) 905-2500

KMF:emg
1600 Tysons Boulevard
McLean, VA 22102
(703) 905-2000
Enclosure: Appendix

APPENDIX
VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

The specification is changed as follows:

Page 1, line 13, change the paragraph to read:

2. [Discription] Description of the Prior Art

Page 1, lines 14-21, change the paragraph to read:

With the recent remarkable increases of the processing rate of semiconductor [device] devices and the degree of integration in semiconductor [device] devices, the heat generated by semiconductor elements has come to produce influences that are not negligible. As a result, substrate materials for mounting semiconductor devices have come to be required to have a high thermal conductivity for efficiently removing the heat generated by semiconductor elements.

Page 9, lines 21-26, change the paragraph to read:

[And aluminum/silicon] Aluminum/silicon carbide composite alloys [has] have a high degree of hardness. Therefore it is very difficult to [forme] form a shape, especially a complex shape such as heatsink by using aluminum/silicon carbide composite alloys. It is required [to] that a substrate material [being] is able to be formed easily to be near net shape precisely.

Page 10, lines 2-9, change the paragraph to read:

In view of the current situation as described above, an object of the present invention is to eliminate the problems concerning precision in forming, cost, etc. to provide a substrate material for mounting a semiconductor device, made of a lightweight aluminum/silicon carbide composite alloy which has a [homogenous] homogeneous composition and has the properties required of a substrate material, i.e., a thermal conductivity of 100 W/m·K or higher and a thermal expansion coefficient of $20 \times 10^{-6}/^{\circ}\text{C}$ or lower.

Page 10, lines 13-17, change the paragraph to read:

Another object of the present invention is to provide a method of forming a substrate which [is controlled] has a thermal expansion coefficient [thereof easily] with a large range so as to be appropriate [to] for a semiconductor chip or a package to be fixed to the substrate.

Page 10, line 20 through page 11, line 7, change the paragraph to read:

To accomplish the above objects, the present invention provides a substrate material for mounting a semiconductor device, made of an aluminum/silicon carbide composite alloy which comprises an Al-SiC alloy composition part and a non alloy part and dispersed homogeneously silicon carbide granular particles. Silicon carbide granular particles are dispersed from 10 to 70% by weight in the composite alloy, and silicon carbide is distributed homogeneously in the Al-SiC alloy composition part. And the fluctuations of silicon carbide concentration in the Al-SiC alloy composition parts is within 1% by weight, and which has a thermal conductivity of 100 W/m·K or higher and a thermal expansion coefficient of $20 \times 10^{-6}/^{\circ}\text{C}$ or lower.

Page 12, lines 14-20, change the paragraph to read:

[Especially the] The sintering process of the present invention for producing an aluminum/silicon carbide composite alloy, is especially capable of yielding an aluminum/silicon carbide composite alloy having a thermal conductivity of 180 W/m·K or higher by regulating the sintering temperature [especially] to a value in the range of from 600 to 750°C to thereby control the interfacial reaction which yields the aluminum carbide and the silicon.

Page 15, lines 3-13, change the paragraph to read:

In the present invention, an aluminum/silicon carbide composite alloy useful as a semiconductor substrate material is produced by sintering to thereby provide a semiconductor substrate material having the desired values of thermal conductivity and thermal expansion coefficient and having a homogeneous Al-SiC composition and a near-net shape, i.e., excellent dimensional precision, the attainment of both of which has been difficult in conventional processes. This substrate material is capable of coping with, not only conventional ceramic [package] packages, and metal [package] packages but also in particular, plastic packages, flip chip bonding, and ball grid array bonding.

Page 15, line 23 through page 16, line 14, change the paragraph to read:

The crystal forms of silicon carbide include hexagonal α -SiC form, which is formed at a high-temperature, and cubic β -SiC form, which is formed at a low-temperature. Although these two forms do not differ in the thermal conductivity of an alloy, α -silicon carbide is susceptible to cleavage. Due to this property, use of α -silicon carbide in a starting powder is apt to result in silicon carbide cleavage due to the pressure applied during compaction into a desired substrate shape. As a result of the cleavage, the compact may contain aggregates made up of fine silicon carbide particles. Since the aggregates have poor adhesion to aluminum in an alloy, they tend to suffer debonding of particles when the alloy is subjected to [processings] processing such as grinding, barrel, shot blasting, etc. in the final step. It is therefore desirable to use β -silicon carbide or a mixture of α -silicon carbide and β -silicon carbide. "Debonding of particles" means that particles are [desplaced] displaced from the position to be in the alloy, and the surface of the alloy [grow] grows porous.

Page 22, lines 14-25, change the paragraph to read:

In ordinary sintering, densification is generally inhibited by the gas remaining within the alloy. However, the use of nitrogen as a non-oxidizing atmosphere was found to be effective in densification because the nitrogen gas remaining within the alloy turns into aluminum nitride through reactions with aluminum. An alloy containing nitrogen especially in an amount of 0.01% by weight or larger is advantageous for attaining a thermal conductivity of 180 W/m·K or higher. However, if the content of nitrogen exceeds 1% by weight, densification is inhibited rather than enhanced. Therefore the preferred range of the nitrogen content in the aluminum/silicon carbide composite alloy is [hence] from 0.01 to 1% by weight.

Page 24, line 24 through page 25, line 2, change the paragraph to read:

And according to aluminum/silicon carbide composite alloys formed as above, a substrate can be formed precisely to be near net shaped or in net shaped without warp or deform. In this case it is not required to [machine processing] machine process with respect to the whole surface.

Page 34, lines 11-20, change the paragraph to read:

The starting powders obtained were compacted at a pressure of 7 t/cm² to obtain tablet test pieces having a diameter of 20 mm and a height of 30 mm. These compacts were

sintered at 700°C for 2 hours in a nitrogen atmosphere having a nitrogen concentration of 99% by volume or higher. As a [results] result, aluminum/silicon carbide composite alloy sinters were obtained which retained the original shape of the compacted test pieces.

However, the alloy of sample 9 was not dense and had voids in a surface layer thereof; this alloy was hence not subjected to the following measurements.

Page 36, line 16 through page 37, line 2, change the paragraph to read:

The starting powders obtained were compacted at a pressure of 7 t/cm² to obtain tablet test pieces having a diameter of 20 mm and a height of 30 mm. These compacts were sintered in a nitrogen atmosphere to remove a binder. Then after degassing the tablet test pieces in a pressured chamber, they were pressure-infiltrated in an aluminum melt. As a result, aluminum/silicon carbide composite alloy having silicon carbide contents of 71 % by weight were obtained. It was difficult to obtain aluminum/silicon carbide composite alloy having silicon carbide contents of less than 70 % by weight by similar method. Because more porosity in the formed silicon carbide compact is required, and the formed silicon carbide compact is not stiff enough to keep [it] its shape.

Page 53, line 21 through page 54, line 7, change the paragraph to read:

An aluminum powder having an average particle diameter of 25 µm was mixed with a silicon carbide powder having an average particle diameter of 35 µm [m] in such a proportion as to result in a silicon carbide content of 50% by weight. The mixture was homogenized with a kneader for 1 hour in the same manner as in the above Examples. Thus, an aluminum/silicon carbide starting powder was obtained. The starting powder obtained was compacted at a pressure of 7 t/cm². The resultant compacts were sintered at 700°C for 2 hours in a nitrogen atmosphere having a nitrogen concentration of 99% by volume or higher. As a result, aluminum/silicon carbide composite alloy sinters were obtained which retained the original shape of the compacted test pieces.

Page 61, lines 2-8, change the paragraph to read:

The starting powders obtained were compacted at a pressure of 7 t/cm² to obtain test pieces having dimensions of 100 mm by 25 mm by 2 mm (thickness). These compacts were sintered at 700°C for 2 hours in a nitrogen atmosphere having a nitrogen concentration of 99% by volume or higher. As a [results] result aluminum/silicon carbide composite alloy sinters were obtained which retained the original shape of the compacted test pieces.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re PATENT APPLICATION OF

Inventor(s): YAMAGATA et al.

Filed: Herewith

Title: SUBSTRATE MATERIAL FOR MOUNTING A SEMICONDUCTOR DEVICE,
SUBSTRATE FOR MOUNTING A SEMICONDUCTOR DEVICE, SEMICONDUCTOR
DEVICE, AND METHOD OF PRODUCING THE SAME

August 10, 2001

PRELIMINARY AMENDMENT

Hon. Commissioner of Patents
Washington, D.C. 20231

Sir:

Please amend this application as follows:

IN THE SPECIFICATION:

At the top of the first page, just under the title, insert:

1. --This is a Continuation-In-Part Divisional
 Continuation Substitute Application (MPEP 201.09) of
 1(a) National Application No. 09/692,162 filed October 20, 2000, which is a Divisional of
Appn. No. 08/874,543, filed June 13, 1997
2. --This application claims the benefit of U.S. Provisional Application No.
 60/____, filed ____--

Respectfully submitted,

PILLSBURY WINTHROP LLP
Intellectual Property Group

By:

KMF
Attorney: Kenneth M. Fagin
Reg. No: 37,615
Tel. No.: (703) 905-2066
Fax No.: (703) 905-2500

Atty\Sec. KMF/emg
1600 Tysons Boulevard
McLean, VA 22102
(703) 905-2000